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CENTRAL INTELLIGENCE GROUP
INTELLIGENCE REPORT

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Comment: Although the following report is in part already known, it is being distributed in its entirety because it is the most complete study on this subject received to date). 50

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I. Maximum Density of Traffic

1. The construction of the canal was divided into two stages:
 - a) The first stage included the canal proper, with the following installations:

Locks	19
Weirs	15
Flush weirs	12
Dams	49 (excluding those not directly on the canal)
Canals	33
 - b) The second stage included the widening of the waterway with change-over (sukhod) to a second line of large locks by the utilization of a series of supplementary reservoirs -- Lakes Kalg, Vanzh, and Konzh, the last-named to regulate the water level of Lake Matko.
2. The projected maximum density of traffic of the canal with one line of navigation constructions (first stage) is, excluding the necessary traffic of rafts and also of passenger and service steamers, 4,000,000 tons in one direction for one navigation season, on the following basis:

Projected duration of passage through lock: 44 minutes.
Fifteen passages through locks in both directions in 24 hours.
Cargo capacity of ship 120 m. long: 3,000 t.
Coefficient of utilization of cargo capacity: 0.8.
Coefficient of irregularity of traffic: 1.5.

II. Hydro-technical Constructions

A. Locke (shlyuz)

3. Of nineteen locks(thirteen two-chambered and six one-chambered), thirteen have been built on a rocky foundation and six on soft ground. The fact that the majority of locks have a rock foundation, combined with the intention of the builders to rely mainly on local materials, led to the extensive employment

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of wooden constructions. Reinforced concrete was employed only in the heads (golova) and foundations.

4. The walls, of sectional wooden construction, are of pile type in the majority of locks, but in lock No. 4 and in the lower chamber of lock No. 3 they are made of piles with a trestle superstructure. On rock foundations, the lower part of the walls is of rock and the upper part of pile superstructures. The interstices between the piles are in every case filled with soft soil.
5. In the locks with foundations on soft ground, the concrete heads are enclosed in ribs (shpunt), the pile walls are set in wooden grillage, and in lock No. 12 a rib (shpunt) has been driven in along the face edge of the walls.
6. The floors of the lock chambers on soft ground are wooden and are on pile framework; those on rocky ground are of levelled rock. Of the total of 51 lock gates, 43 are of wood and eight of metal. These gates are everywhere of standard type with vertical axes. The wooden gates are of original diamond-shaped construction, and the metal ones are of cross-bar type (rigelni) with wooden facing.
7. The filling and emptying of the chambers is effected through openings at the heads of the locks. Reduction of the force of the jet is obtained by an arrangement of shock-absorbing walls (deepenings) located lower than the sills and walls of the fall. The water openings are fitted with cylindrical shutters with screw elevators.
8. The machinery for opening the gates is of rack type with winches.
9. The emergency gates consist of two wooden sections revolving on vertical axes and placed open in special recesses between the upper piling (pal) and the heads. Locks Nos. 1, 3, 4, 13, 15, and 17 have no emergency shutters but have upper repair shutters instead. Repair shutters are of two types: of spokes, with the point of support of the top of the spokes in a floating pontoon (made by GAU firm); and of strut type. For the former type, a recess is arranged in the piling; for the latter, in the flood-bed (flyutbet).
10. The approaches to the locks are secured by straight sections of the canal with an arrangement of long straight and short curved piling.
11. Navigation equipment consists of berthing bollards, protective beams, barriers for tractor propulsion, and signal masts at the extreme heads of all locks.

B. Weirs

12. According to the nomenclature of the builders, the designation "weir" (plotina) is given to two principal types of retaining constructions which bar the natural beds of rivers and their channels.
 - a. Those regulating the levels and flows of river and lake reaches created by them.
 - b. Those maintaining the levels of these reaches.
- In addition, "Poare" No. 34 weir has been built on Canal 165 for emergency.
13. Weirs of the first type are on rock foundations at the heads of those sections of the river Nizhni Vyg which contain rapids, at each of the junctions of the north slope of the waterway.
 - a. Weirs Nos. 21, 25, and 27 (Nadvoitsi, Palokorgski, and Matkohnenski junctions) are of reinforced concrete with standard openings for letting through water, with a span of 12.1 meters each and with covering segmental shutters (zatvor)
 - b. Weirs Nos. 25 and 27, in addition, have ice overflows: the former with spoke shutters on the crown, the latter without shutters.

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- c. Weirs Nos. 23 and 29 (Shavanski and Vygostrovski junctions) are of blank, overflow type, made of wood, of sloping pile framework filled with stone, with smoothly outlined overflow faces. The piers of the first weir are of concrete, and those of the second of piles. Next to weir No. 29 there is a wooden flush weir (vodopusk).
14. Weirs of the second type are made of earth with a stone outline, in the majority of cases on weak filter foundations; these constructions differ from the dams erected in the catchments of rivers only in the details of construction of their bodies, according to the conditions of the execution of the building works in river beds. Earth weirs have been built at:
- a. The source of the Povenchanka River (No. 20).
 - b. At Nadvoitski, Shavanski, Palokorgski, Matkozhnenski, and Vygostrovski junctions on Nizhni Vyg River (Nos. 22, 24, 28, 30).
 - c. On the Shizhnaya and the right channel of the Nizhni Vyg River (Nos. 31, 32, and 33).

C. Canals

15. Artificial navigable canals, protected on one or both sides by dikes (damba), have a total length of 13,779 meters or 6% of the length of the whole waterway. For a length of 20,000 meters (9% of the total length of the waterway) deepening and cleaning work has been carried out.
16. The dikes protecting canals are of quadrangular section with a crown from 5 to 6½ meters wide, with embankments with ratio of slope from 1:1½ to 1:4½ meters. On the canal side the embankments are protected by stone facing. In the majority of dikes the facing extends from the base to the crown; but in some cases, according to the kind of soil, the protection has not been carried down to the base.
17. The total length of dikes not directly on the canal is 15.6 kms.

D. Dams (Damba)

18. The waterway has 49 dams, which may be divided into three types according to their purposes and excluding those not directly on the canal:
- a. Retaining (podporni) dams (belonging to junctions and forming, with the weirs, a system of retaining reaches):
 - Nos. 41 to 49 inclusive on the Povenets slope
 - No. 81 on Khizhozero
 - Nos. 50, 67, and 79 at Lock No. 8
 - No. 51 at Lock No. 9
 - Nos. 61, 62, and 63 at Shavanski junction
 - Nos. 66 and 67 at Palo-Korga
 - Nos. 70 and 71 at Matkozha
 - Nos. 74 and 75 on the Shizhnaya
 - b. Protective dams (located outside the junctions)
 - No. 82 on Khizhozero
 - Nos. 52, 78a, and 78b on Lakes Matko and Toros
 - Located on the shores of Lake Vyg: Maigubski Nos. 53a,b,c,d, watershed dams with Onda Nos. 54 and 55; Letirucheiskaya Dam No. 56, Dubrovskaya No. 57, and Verrogubskaya No. 58.
 - Shavanski Dams Nos. 65a, b, c, and d
 - Palokorgski Dams Nos. 68a, b, c, and d
 - Matkozhnenski Dams Nos. 72a and b
 - Shizhnenski Dam No. 76

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Dams Nos. 59 and 60 on the overflow canal may also be included in this category.

- c. Regulating parallel construction: Dam No. 180 (pressureless, improving the approaches to the locks from the wide riverbed or lake reaches).

All the dams are built of local soil and in nearly every case are located on weak filter foundations.

19. The dams are represented by 3 types of construction:

- Homogeneous, made of fine-grained soil.
- Made of coarse-grained soil with a water-tight screen (of peat, plastic clays, and clay, according to local resources).
- Mixed, made of earthen "otsyp", supported by a stone terrace.

In individual cases screens have been built for dams of mixed construction.

20. The length of the dams varies from several tens of meters to $3\frac{1}{2}$ km (Dubrovskaya) and the height from $1\frac{1}{2}$ (pressureless and protective) to 13 meters (Letiruchenskaya). The width on top is 5 m. in nearly every case, excluding the strengthening strip of 1.08 m. There is a reserve height of $1\frac{1}{2}$ m. above the maximum water-level. The slopes have a foundation corresponding to the nature of the soil and are reinforced: upper of stone and lower of earth, grassed and turfed.

E. Flush Weirs (Vodopusk)

21. Of twelve flush weirs, ten are operating weirs and two are emergency (overflows).

- a. Flush weirs are in the form of wooden culverts with pile upstream and downstream heads and are located in the body of the earth dams and weirs of the Khizhovorovski Reservoir (No. 141), Povenchanski (Nos. 130, 131, 132), Telekinski (Nos. 133, 134) Palo-Korgski (No. 135), and Shizhenski (Nos. 138, 139, 140) stepped locks. The flush weirs of stepped locks are intended for the overflow of lateral tributaries (determining their maximum density of traffic) and for emptying canals and reaches, in addition to regulating the navigable water-levels.
- b. Overflow dams Nos. 136 and 144, in the form of sluice canals, have been built to prevent Canal No. 185 and the head water of Lock No. 5 from overflowing in the event of damage to the gates of the locks located higher up.

22. Wooden flush weirs were not solid enough and were therefore replaced later on by concrete ones without in any way interfering with the normal working of the canal.

III. Water Economy of the Canal

23. From the point of view of its water economy, the canal is divided into the following principal sections:

- A. Povenchanskaya Stairway
- B. Lakes Volo, Katko, Uzkis, and Vodlo
- C. Lake Katko
- D. Lake Vyg
- E. Nizhni Vyg River
- F. Diversion Canals
- G. Shizhenskaya Stairway

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A. Povenchanskaya Stairway

24. The Povenchanskaya Lostnitsa (Stairway), covering the south slope of the waterway, consists of small water reaches with unimportant local tributaries. These reaches are formed partly by the damming (podpor) of the bed of the Povenchanka River (reaches between locks Nos. 2-3, 5-6, and 6-7) and partly by diversions of the bed of the same river (reaches between locks Nos. 1-2, 3-4, and 4-5).
25. In all these reaches the fundamental question of water economy is the regulation of the fluctuation of the level from the ebb and flow of the lock prisms (prizm). The flow from Lake Volo into the Povenchanka River has been completely cut off and all the overflow waters from the watershed reach go north. The lateral tributaries, feeding the Povenchanka River, have an extraordinarily small average of flow - about 0.01 cub.m./sec per sq. km. The following table speaks for itself:

Water Surface between locks Nos.	Weir No.	Area of water collection in sq. km.	Average quantity of water in cub.m./sec.	Max. quantity of water in cub.m./sec
7-6	132	5.5	0.055	5
6-5	131	30.5	0.305	22
3-2	130	36.8	0.370	25

26. The passage of the spring flood waters along the Povenchanka River is effected through weirs (vodopusk). There are no weirs in the diversion reaches in view of the unimportant local areas of water overflow. The fluctuation of the levels of the reaches of Povenchanskaya Lostnitsa from the ebb and flow of the lock prisms is shown in the following table:

	Reach between Locks Nos.					
	1-2	2-3	3-4	4-5	5-6	6-7
High level	42.90	53.65	64.60	75.45	86.15	96.80
Low level	42.70	53.50	64.30	75.10	86.05	96.65
Fluctuation	0.20	0.15	0.30	0.35	0.10	0.15
Area of surface in 1,000 cub.m.	230	280	125	106	870	320

27. Emergency overflow No. 144 with capacity of 80 cub.m./sec has been installed to avoid the overfilling of the reaches between Locks 4 and 3 in the event of a breach in the gates of Lock No. 4.

B. Lakes Volo, Katko, Uzkie, and Vodlo

28. The watershed reach includes the group of Lakes Volo, Katko, Uzkie, and Vodlo, connected with one another by short canals. By raising the level of the lakes from 2 to 4 meters and by digging watershed canal No. 165, a common reach with an area of 40 sq. kms. has been created between Locks 7 and 8.
29. The water supply of the reach is determined by hydrometeorological methods of establishing the norm of flow according to the norm of precipitations (550mm.) and the co-efficient of the flow (0.60). The latter is determined by the deficit of humidity on the analogy of the basin of Lake Vyg. The area of water collection of the reach is fixed at 898 sq. kms.

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30. Annual in-flows (pritok) are estimated as follows: maximum - 478 million cub.m., average - 283 million cub.m., and minimum - 184 million cub.m. The minimum low-water flow may fall to 1.3 cub.m./sec.
31. The quantity of water for locking (shlyuzovanie) is calculated at the rate of 6 cub.m./sec, flowing out of 24 lock prisms (prizma) per 24 hrs. on each slope (32 lockings with a coefficient of irregularity of 1.3). Quantity of water wasted on both inclines is calculated at 3 cub.m./sec and the total quantity, calculating the maximum navigation period at 180 days, is estimated to be about 140 million cub.m. for the period.
32. The annual inflow even in a dry year covers consumption for locking and wastage throughout the navigation period by regulating the inflow to cover the deficit of the low-water period. The regulating of the inflow is achieved by creating an effective capacity of 20 million cub.m. in the main reach (layer of variation 0.5m.) and by the creation of the Khizhozero reserve reservoir with effective capacity of 90 million cub.m. (with planned requirement of 50 million cub.m.).
33. The maximum overflow (sbrozny) quantities from the supplementary Khizhozero reservoir are estimated in the plan on the basis of the incidence of high water of maximum dimensions, possible once in a hundred years. The following reserves are allowed for the accumulation of high water: at Khizhozero 0.30m; on the watershed 0.40m. The maximum overflow consumption in these conditions is for Khizhozero 35 cub.m./sec and for the watershed 110 cub.m./sec.

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35. Amplitude of fluctuations of the level in the watershed reach is 1.30m., with deviations from the mark of 102 to 103.3m.; and at Khizhozero 6m., with deviations from the mark of 108.2 to 114.2m.

C. Lake Matko

36. The consumption for locking in the Matkozero reach is replenished by feeding (raskhod) from the watershed reach, in view of the approximate equality of the pressure falls (napor) at Locks Nos. 8 and 9. On the strength of this, regulation of the water discharge (stok) of Matkozero is not necessary.
37. The maximum overflow equals 90 cub.m./sec. with a reserve for accumulation of high water of 0.30m. Estimated overflow through flush weir (vodopusk) No. 134 at Lock No. 9 is 200 cub.m./sec.
38. The total amplitude of fluctuations of the level is 0.80m. taking into account a "sgon" of 0.10m., accumulations of 0.30 m., and "nagon" from the 94.30m. to the 93.50m. mark.

D. Lake Vyg

39. The water collection area of Lake Vyg is 19,080 sq. kms. The average perennial inflow is 193 cub.m./sec. with a range of fluctuations of flow from 60 to 2,750 cub.m./sec. The area of surface (zerkalo) is 1,200 sq. kms. The consumption for locking from Lake Vyg is frequently covered even by the minimum inflow.
40. The scheme for regulating the discharge of Lake Vyg provides for reducing the rise of the level (gorizont) at the time of the high water by lowering the level of the low navigation period (89.05m.) to the lowest winter level (88.65m.). To accelerate and facilitate the passage of ice (ledokhod) through the dam on the river Vyg by overflows from Lake Vyg, a reserve of

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200 million cub.m. has been provided for at the time of the spring floods.

41. The low-water flow on the river Nizhni Vyg at 100 cub.m./sec is ensured by accumulating water in Lake Vyg to the level of the 69.25m. mark.
42. The estimated overflow (catastrophic) consumption from Lake Vyg through Dam No. 21 is 800 cub.m./sec. and the maximum spring level is 69.6m.
43. In view of the large area of the surface of the lake (over 1,200 sq. kms), a reserve of one meter is allowed for "nagon" and of 0.4m. for "sagon", and the total navigation amplitude of fluctuations of the level is 1.95m. from the 68.65m. to the 70.6m. mark.

E. Nizhni Vyg River

44. River-bed reaches of the Nizhni Vyg River are as follows: Shavanski between Locks Nos. 10-11, Palo-Korgski (Locks Nos. 11-12), Matkozhanski (Locks Nos. 13-14), and Vygostrovski (Locks Nos. 15-16).
45. The area of water collection from the source of the Nizhni Vyg River out of Lake Vyg to Vyg Island is 8,955 sq. kms. and gives an average perennial flow of lateral tributaries of 90 cub.m./sec, falling at low water to 15 cub.m./sec and rising in the spring to the maximum limit of 1,200 cub.m./sec (once in a hundred years). The main part of the water collection area and of the lateral tributaries is concentrated in Palo-Korgski reach between weirs (plotina) Nos. 23 and 25. The water collection area of the Shavanski reach is only 25 sq. kms. with extremely limited lateral tributaries.
46. The dammed water-levels (podporny gorizont) or river-bed reaches have been selected so as not to exceed the mean velocity of flow of one meter per second in the river-bed, with a maximum spring flow. This condition has been maintained in all sectors except that above the Onda River on the Palo-Korgski reach, where the mean velocity is maintained above 1 meter per second, for fifteen days in an average year reaching the limit of 1.8 meters per second.
47. The estimated maximum (catastrophic) and minimum flows of the weirs in the river-bed of the Nizhni Vyg River and their corresponding levels in the upper water are as follows:

Weir No.	Name of Weir	Estimated quantities in cub.m. per sec.		Levels of upper water	
		Max.	Min.	Max.	Min.
23	Shavanskaya	800	15	78.0	75.5
25	Palo-Korgskaya	1,850	100	60.3	60.0
27	Matkozhnenskaya	2,000	100	47.5	45.5
29	Vygostrovskaya	2,000	100	27.5	25.5

48. The levels of the upper and lower waters of locks Nos. 11-16 are subject to great fluctuations, as shown in the table below:

Lock No.	Level of water of upper reach		Level of water of lower reach	
	Highest	Lowest	Highest	Lowest
11	78.00	75.50	62.40	60.00
12	60.30	60.00	55.30	55.20
13	55.30	55.20	48.90	45.50
14	47.50	45.50	37.50	35.50
15	35.70	35.50	27.90	25.50
16	27.50	25.50	15.40	15.30

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F. Diversion Canals (Derivatsionny Kanai) Nos. 181 and 185

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49. The water collection area of Canal No. 181 is 6.5 sq. kms. and the estimated catastrophic flow is 6 cubic meters per sec., which has also been accepted for the productive capacity of flush weir (vodopusk) No. 135.
50. The water collection area of Canal No. 185 is only 2 sq. kms., with maximum flow of 2 cubic meters per second. A special flush weir has not been built in this reach in view of the existence of overflow (vodosbros) No. 136, installed in case of damage to the gates of Lock No. 14.
51. Supplementary feeding of Canals Nos. 181 and 185 in case of necessity is obtained through the water galleries of Locks Nos. 12 and 14. The fluctuation of the levels from the overflow and flood (priliv) of the lock prisms is: on Canal No. 181, 0.10m. from the 55.20m. to the 55.30m. mark; and on Canal No. 185, 0.20m. from the 35.50m. to the 37.70m. mark.

G. Shizhnenskaya Stairway

52. Shizhaenskaya Stairway includes the reaches between locks Nos. 16-17, 17-18, and 18-19. The reaches on the Shizhnenskaya Stairway are formed in the valley of the tributary Shizhnaya. The discharge from the Vyz River into the Shizhnaya has been stopped completely except for the quantities required for locking. The local inflow is insignificant, and flush weirs Nos. 138, 139, and 140 have been built for its passage in the winter floods. These flush weirs have the following water collection areas and estimated flows:

Flush Weir No.	Water collection area in sq. kms.	Estimated catastrophic flow in cub.m. per sec.
138	11	9
139	16	13
140	25	18

53. The calculated levels of fluctuation of the levels of the reaches, caused by the overflow (sliv) and flood (priliv) of three lock prisms, and the areas of the water surface are characterized by the following indices:

Reach between Locks Nos.	Low level	High level	Fluctuation of level	Surface area in 1000 sq.m.
16-17	15.30	15.40	0.10	410
17-18	9.75	9.80	0.05	840
18-19	4.15	4.20	0.05	850

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